OPERATIONS AND MAINTENANCE MANUAL

ATMOSPHERIC CONTAMINANT SENSOR

(NASA-CR-128602) OPERATIONS AND MAINTENANCE MANUAL, ATMOSPHERIC CONTAMINANT SENSOR. ADDENDUM 1: CARBON MONOXIDE MONITOR MODEL 204 (Perkin-Elmer Corp.) Mar. 1972 23 p CSCL 14B G3/14
N73-11394
Unclas
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PERKIN-ELMER

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CR - 128602

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ADDENDUM 1
OPERATIONS AND MAINTENANCE MANUAL
CARBON MONOXIDE MONITOR
MODEL 204

March 1972
Revision B
Perkin-Elmer SPO 30249
NASA Contract Number NAS9-12066

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Houston, Texas
77058

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1. INSTRUMENT DESCRIPTION

1.1 THEORY OF OPERATION

The Type 204 carbon monoxide monitor is a nondispersive infrared instrument intended for continuous monitoring of low levels (0-100 millitor) of Carbon Monoxide, Fig. 1-1.

1.2 SYSTEM FEATURES

The instrument has exceptional inherent span stability which is augmented by a closed loop span control system making span calibration unnecessary in normal use. In addition, there is an internal zero mechanism controlled from the front panel which makes external zero gases unnecessary. The stability and specificity of this instrument makes normal operation extremely simple.

1.3 CONTROLS AND MONITORS

1.3.1 POWER: Circuit breaker/Power switch. Power to the instrument is switched by the circuit breaker on the front panel.

1.3.2 NO GO indicator: The instrument contains self-checking circuits which monitor critical functions and will indicate NO-GO if conditions exist which may produce incorrect readings.

1.3.3 LAMP TEST switch: This switch tests the NO-GO indicator and its driving logic. Since in normal operation, all indications are off, the Lamp Test switch can also be used to verify the instrument power-on condition.

1.3.4 ZERO-OPERATE switch: This switch actuates a solenoid placing an alternate optical path between the infrared source and detector. This path is filled with CO free gas, eliminating the need for zero calibration gas.

1.3.5 ZERO indicator: Indicates that the zero CO optical path is in place. The instrument will not monitor the ambient carbon monoxide level when this light is showing.

1.3.6 ZERO potentiometer: Adjusts the zero reference level of the instrument.

1.3.7 Cooling Inlet Filter: Filters inlet cooling air. This filter must be kept clean.

1.3.8 OVERTEMP Indicator: Indicates instrument shutdown by internal thermal switch. This is most likely to result from a clogged cooling air inlet filter.

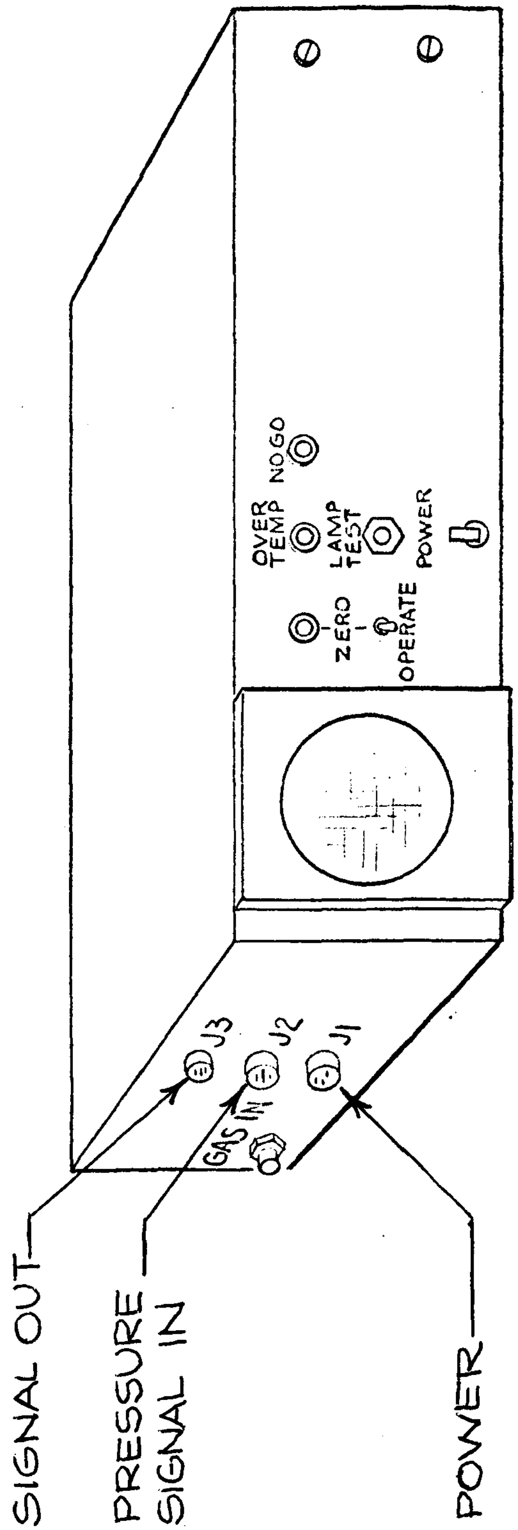

SIGNAL OUT
PRESSURE SIGNAL IN
POWER
GAS IN
J3
J2
J1
ZERO
OPERATE
OVER TEMP
LAMP TEST
NOGO
POWER

FIG 1-1

1.4 DETAILED FUNCTIONAL DESCRIPTION

1.4.1 The 204 is a nondispersive infrared (NDIR) instrument employing unique infrared emitting and modulating techniques providing very specific (i.e., insensitive to other gases) sensitivity to CO. It contains zeroing apparatus which permits setup without cumbersome zero gases. Similarly, exceptional inherent span stability makes span gases unnecessary. A closed loop span system assures long-term measurement accuracy despite normal variations in optical transmission.

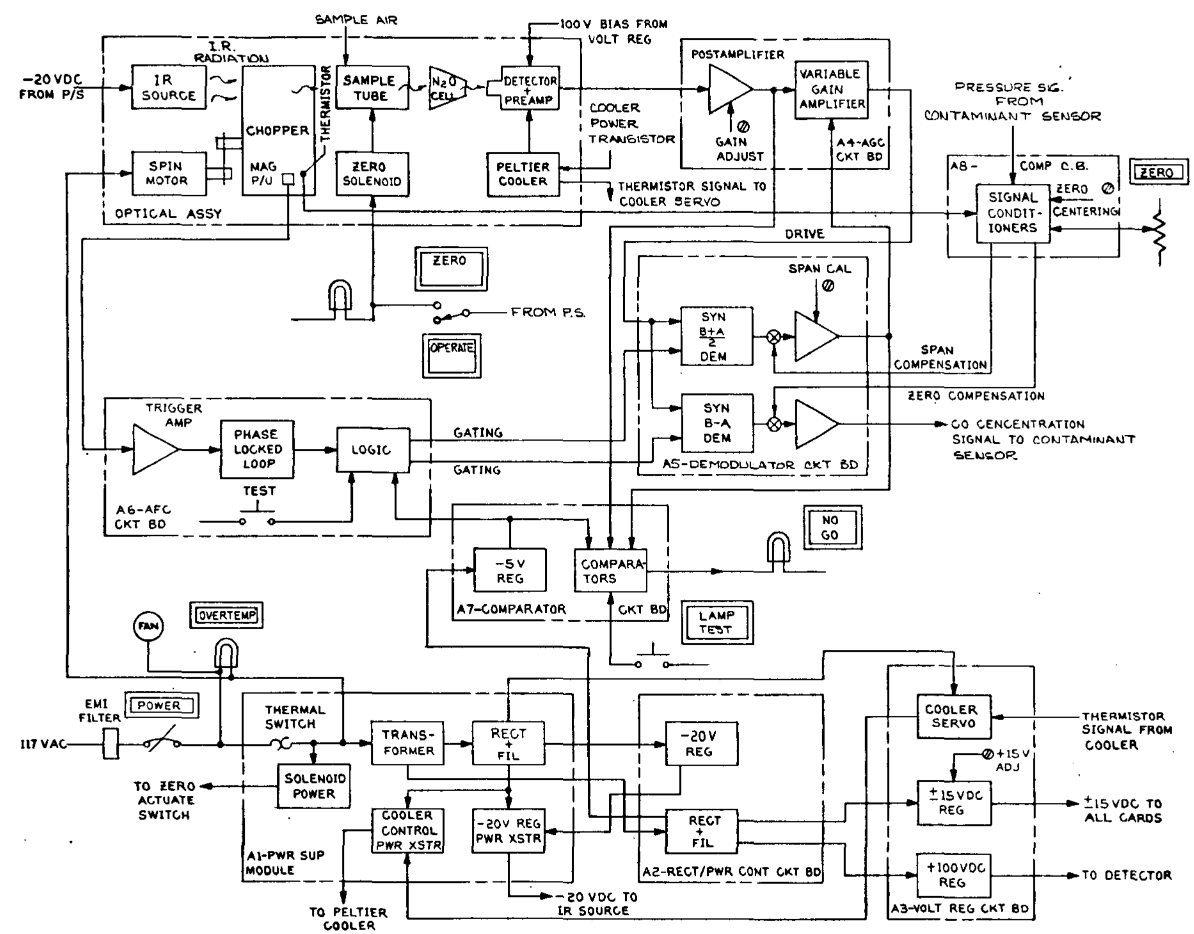
1.4.2 The basic source of infrared (IR) radiation is a hot-filament "blackbody" IR emitter, hereafter called the source. The output of the source is directed to the chopper assembly which modulates the incoming, spectrally broadband radiation producing a series of radiation pulses which are then allowed to shine through the sample tube and hence through the sample gas it contains. These pulses are alternately of two kinds, an "A" pulse which will be reduced in intensity in proportion to the amount of CO present in the sample tube, and a "B" or reference pulse which is unaffected by CO in the sample tube. The set of two pulses A and B occurs once for each revolution of the chopper, or nominally 100 times per second.

1.4.3 After passing through the sample tube, the modulated IR radiation, now in the form of the A and B pulses, is allowed to fall on the IR detector, which produces a small electrical signal, in fact, a several millivolt-high series of pulses corresponding exactly to the A and B radiation pulses described above. It is these signals which will subsequently be amplified and processed to extract the information which corresponds to the concentration of CO. This information is contained in the reduction of the A pulse amplitude relative to the B (reference) pulse. Refer to block diagram (Fig. 1-2) and waveform tables.

1.4.4 The detector signal is amplified by a fixed-gain low-noise preamp and transmitted by cable to the post amplifier in the AGC circuit card A4. If the signal level exceeds approx 5.6 VPP, circuits in the Comparator Circuit Board detect the condition and generate a NO GO, displayed both on the front panel and the comparator circuit card, the latter of which also indicates OVERSIG.

1.4.5 The variable gain amplifier on the AGC circuit board receives the signal from the postamplifier and produces signals which, through the action of the closed loop span circuits, are made constant at approx 4 VPP, even though the postamplifier signal may vary from 5 VPP to 2 VPP or less.

1.4.6 The variable gain amplifier is controlled by a voltage called "AGC drive", generated by the demodulator circuit board. However, since the variable gain amplifier also drives the demodulator, we have a closed loop circuit which constitutes the closed loop span system.



BLOCK DIAGRAM
MODEL 204 CO MONITOR
FIG 1-2

1.4.7 The outputs from the AGC circuit board are delivered to the demodulator circuit board where the A-B-A-B pulse train is synchronously rectified, amplied, and filtered to form two varying DC signals. The first signal corresponds to the difference in amplitude between the A and B pulses, which becomes the final CO concentration signal. The second corresponds to the sum amplitude of both pulses, which becomes the "AGC drive" signal and is fed back to the variable gain amplifier on the AGC circuit board as part of the closed loop span system.

1.4.8 Synchronous rectification in the demodulator circuit board is produced by the action of FET switches. The FET switches are driven by digital-type pulses originating in the AFC circuit board A6.

1.4.9 The synchronous rectifier is controlled by waveforms synchronized to the A and B pulses, or in other words, synchronized to the rotating chopper. The generation of the gating signals and the means of synchronizing them to the chopper is accomplished by the AFC Circuit Board.

1.4.10 The AFC board, A6, receives a trigger pulse from the chopper magnetic pickup and produces a pulse once per revolution timed to coincide with the peak of the "A" signal. The trigger pulse is amplified, shaped and applied to a phase-locked-loop (PLL), which constitutes most of the circuitry on the AFC circuit board. The phase locked loop contains an oscillator which is forced to run at eight times the chopper frequency. The resulting 800 hz signal is divided down to 100 hz by an 8-phase shift counter and compared with the 100 hz trigger signal. If the divided-down frequency does not match the trigger frequency, the PLL acts to adjust its oscillator until the two frequencies are precisely matched. The shift counter produces the demodulator's synchronous rectifier gating signals, called "Gating-1" through "Gating-6".

1.4.11 For convenience in trouble-shooting, the AFC circuit board contains a self-test switch, which sends a control pulse train to the AGC board. This causes an upscale span increment of approx 50% FS. This test will only work if the optical system and the A and B signals coming from it are in good order. Moreover, it completely tests the rest of the system including the closed loop span circuits.

1.4.12 The 204 contains a continuous self-check function which will generate a NO-GO on the panel if any of the following occur:

a) Excessive postamplifier signal

b) Insufficient postamplifier signal resulting in closed loop span's AGC drive voltage to be too far negative.

c) Closed loop span fault, resulting in AGC drive voltage to be too far positive.

These self-check circuits are all part of the comparator assy. In addition to generating a panel NO-GO, the comparator has 5 diagnostic indicators which include a GO indicator as well as a NO-GO. These are 3 other indicators which, if a NO-GO is displayed, indicate which of the above abnormal conditions exist.

1.4.13 115 VAC 60 hz main power is brought in through J1 and switched by breaker CB1 on the control panel, then routed to Power Supply A1, where it first goes through the thermal switch which will shut down instrument power if the ambient temperature is excessive or if cooling is impaired. The 115 V is subsequently routed to the chopper spin motor, zero tube solenoid actuation circuits, and power transformer T1. T1 developes the several isolated secondary voltages necessary for the instrument's electronic systems. These secondary voltages are applied to their respective rectifier and ripple filters.

1.4.14 The (+) and (-) 15V regulators provide stable, well-regulated voltages to the signal conditioning circuits. The primary voltage reference for the system of regulators is a stable 9.0 V reference zener diode in the + 15 V regulator. Only the + 15 V is adjustable; the - 15 V is non-adjustable, being referenced to and tracking the + 15 V. All other regulators are referenced to and track the - 15 V, and are also non-adjustable.

1.4.15 The - 20 V regulator developes - 20 VDC at 15 W which is used to power the IR source. This regulator uses the - 15 V as its reference.

1.4.16 The + 100 V is a shunt regulator providing low-noise bias voltage to the IR detector.

1.4.17 The - 5 V regulator is located on the comparator circuit board and powers the comparator circuits as well as logic on the AFC board.

1.4.18 The cooler servo is not a constant voltage supply but a constant temperature control loop using a thermistor (integral with the IR detector) as the temperature sensing feedback element. This circuit maintains the IR detector at a constant - 30° C, necessary for the detector's proper operation.

2. OPERATIONAL PROCEDURES

2.1 TURN ON

The instrument is turned on with the main power breaker. It is operational as soon as the no-go light is extinguished, however, a one-hour warm up should be allowed before zero calibration.

2.2 ZERO CALIBRATION

2.2.1 Actuate the ZERO-OPERATE switch. This places a "Zero CO" sample in the optical path. The zero indicator shows when this sample is in place and therefore not monitoring ambient CO.

2.2.2 Adjust the 10-turn ZERO control for a reading of 6 millitorr on the CO digital readout. Five dial numbers on the ZERO control correspond to 1 millitorr CO. (For example to decrease the reading by 3 millitorr, turn the ZERO controls 15 dial numbers counterclockwise.)

2.2.3 When the readout shows 6 millitorr, turn the ZERO control 30 dial numbers counterclockwise and note the setting in the Atmospheric Contaminant Sensor Operational Data Log.

2.2.4 Set the ZERO-OPERATE switch to the operate position. The instrument is now zeroed and ready for operation.

2.3 READING

2.3.1 Record the partial pressure of CO on the Atmospheric Contaminant Sensor Operational Data Log.

2.3.2 Every 24 hours the CO monitor should be zeroed as in 2.2. If an abnormally high or low reading occurs, the monitor should be zeroed to verify the level.

3. MAINTENANCE AND TROUBLESHOOTING

WARNING

This instrument contains voltages up to 200V capable of delivering dangerous electrical shock. Always disconnect power cable before performing repairs. Use proper precautions when performing troubleshooting under power.

3.1 The Type 204 analyzer is modular in construction to facilitate maintenance. Most of the electronics is on easily replaceable plug in circuit boards, for which spares are normally provided. The power supply may be readily removed for bench repair. In the event of difficulty in the optical assembly, the instrument should be returned to the factory for repair. The only exception to this is failure of the chopper drive belt, which may be replaced in the field (see procedure below). Front panel indicator lights may be replaced without opening the panel.

3.2 Indicator lights on the panel and diagnostic lights on board A7 are intended to help identify the probable cause of improper operation, as well as indicate operating modes.

3.3 To gain access to the electronics, release the two fasteners at the panel's right edge and swing the panel open. If operative tests are required with the door open, it should be opened as little as possible to ensure an adequate supply of cooling air.

3.4 Always establish that regulated supply voltages are good before further tracing of problems. The +15, -15, +100, -5V, and -20V are critical to all instrument functions.

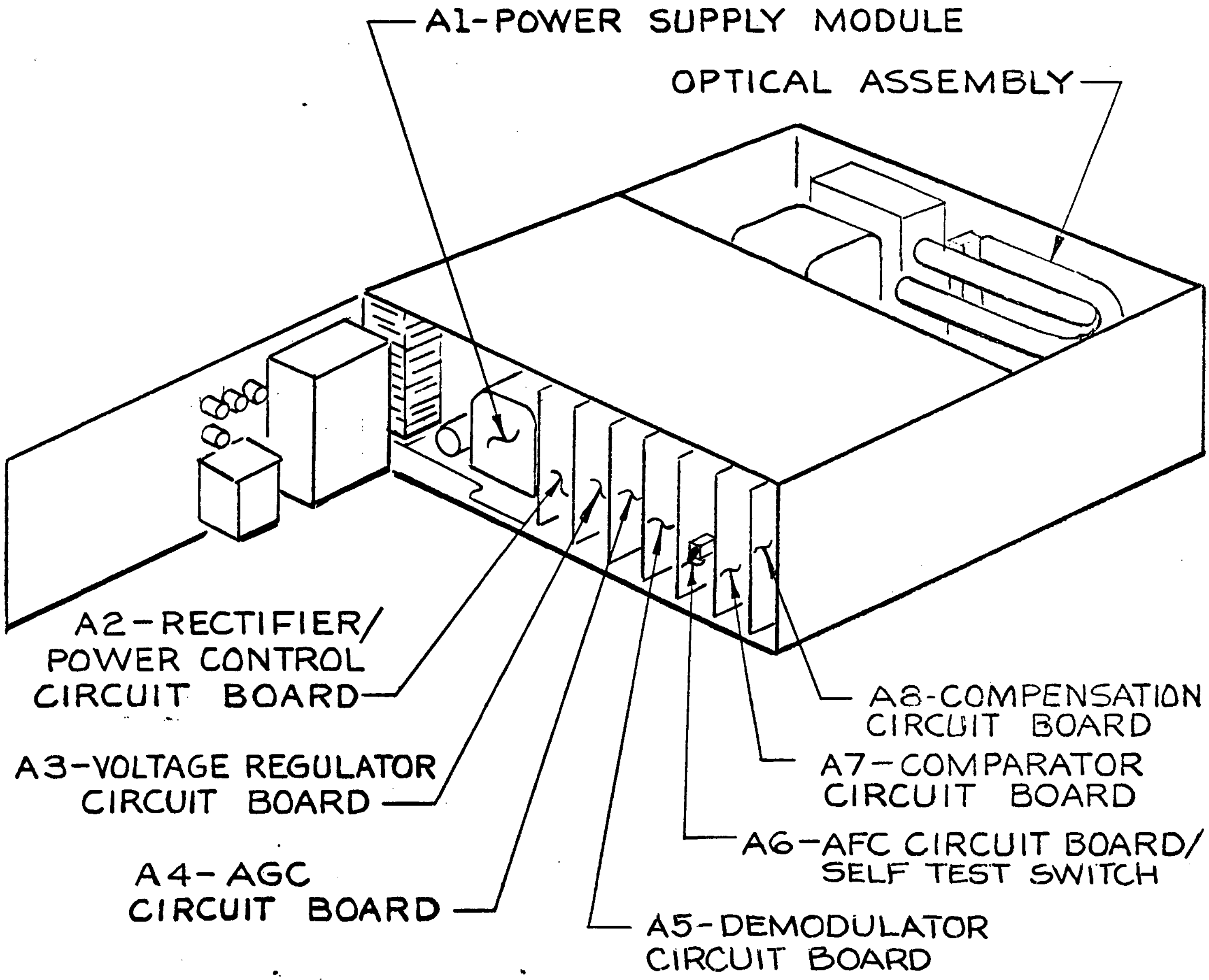

A1-POWER SUPPLY MODULE
OPTICAL ASSEMBLY
A2-RECTIFIER/ POWER CONTROL CIRCUIT BOARD
A3-VOLTAGE REGULATOR CIRCUIT BOARD
A4-AGC CIRCUIT BOARD
A5-DEMODULATOR CIRCUIT BOARD
A6-AFC CIRCUIT BOARD/ SELF TEST SWITCH
A7-COMPARATOR CIRCUIT BOARD
A8-COMPENSATION CIRCUIT BOARD

FIG 3-1

3.5 Troubleshooting Guide

Symptom	Corrective Action	Comments
1. No response; unit appears dead, fan not running, all lights off.	Check power cable and that unit is receiving power. Check power switch is on.	
2. OVERTEMP lit.	Clean air filter, allow unit to cool before reapplying power.	
3. No response; unit appears dead, but fan running.	Press Lamp Test, NO-GO should light. If NO-GO lights, problem is in AFC, AGC, or Demod board; identify by substitution or checking voltages per Tables 3-1, 3-2 and 3-3. If NO-GO does not light, turn power off for 3 sec and back on. Check voltages at A2. If these are faulty, the problem may be in power supply A1. If these voltages are OK, the problem could be regulator failure on A7 or A3, or short or overload fault in any board. Check by substitution or checking voltages per Tables 3-1, 3-2, and 3-3.	

3.5 **Troubleshooting Guide** (cont'd)

Symptom	Corrective Action	Comments
4. Unit appears to be running, voltages check OK, no response to CO.	Check that ZERO-OPERATE switch is in operate position. ZERO light should be out.	
5. Output pegged offscale either end	Check Demodulator by substitution. Cycle power. Check lights on A7: If OVERSIG is lit, replace AGC board. If GO is lit, replace AGC or Demodulator board.	For most symptoms, a good check is to excercise the system self test. This is done by holding the button on A6 down for 1 minute, which should produce on upscale reading increment of approx 50 mtorr at nominal pressure (760 torr) decreasing to 33 mtorr at 506 torr and increasing to 66 mtorr at 1013 torr. (This test is not valid unless the GO indicator on A7 is lit.) If the test fails, the problem lies in: A3 AGC board or A5 AFC board or, A4 Demodulator board or A1 Power Supply. If the problem persists after all voltages and waveforms are found to be OK and all boards have been substituted, the problem lies in the system wiring or the optics assy. In the first case, visual inspection for

Symptom	Corrective Action	Comments
		faulty wiring may be performed. However, malfunction of the optics assy (except replacement of drive belt) requires factory service.
6. Large zero offset or cannot get correct zero	Check wave at A4-F6: If normal, replace A4, A5, or A6, as req'd.	
	If signal is not in spec, check cooler servo voltage at A3-D. If normal, optics assy probably defective. If abnormal, replace A3, A2, or check power Replace A8 Chopper drive belt slipping or broken - Tighten or replace.	The cooler servo voltage at A3-D will vary with temperature, but it will be ~ 0.6V at room temp conditions. If this voltage is >1.0V at room temp, incorrect cooler servo operation exists. The problem could be A1, A2, or A3, or the IR detector in the optics (factory service item).
	If AGC LO is indicated on A7, check signals at A3, A4, and A5.	
	Remove top cover and visually check operation of the tube switching mechanism. If tubes rotate freely by hand but do not respond to switch, solenoid or wiring is faulty. See power supply schematic fig. 3-2 If mechanism does not	The instrument can be zeroed with CO free gas or gas with a known CO concentration. Introduce CO free gas to sample tube and zero per 2.2. OR Introduce gas with

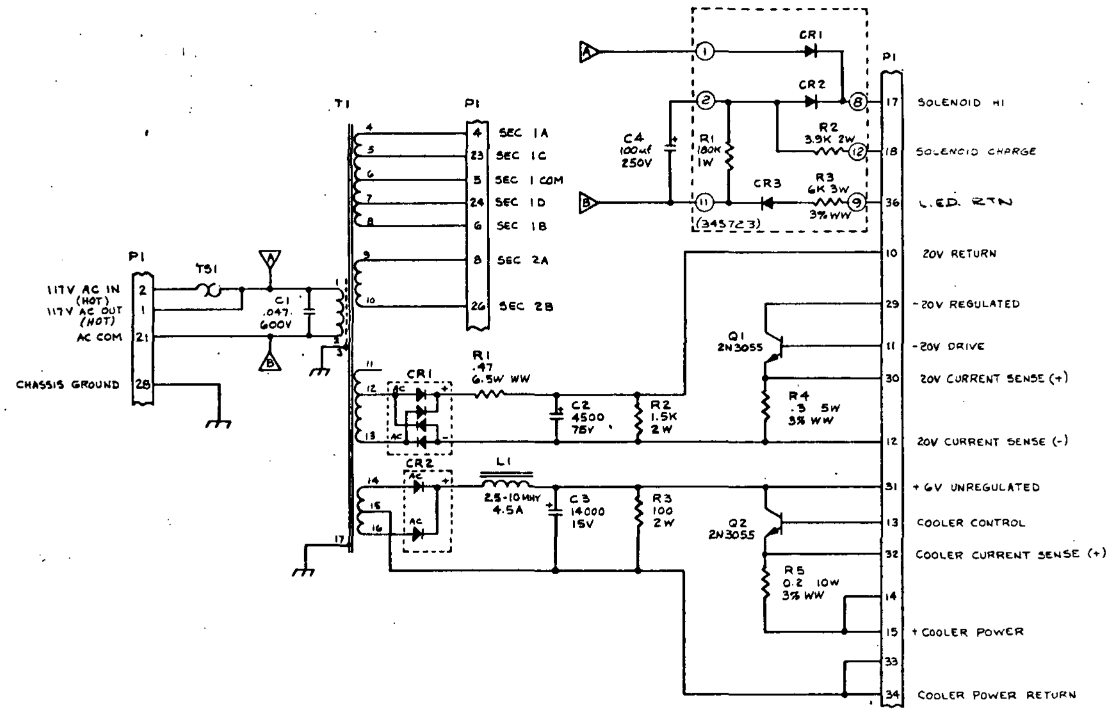


FIG 3-2

NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTOR VALUES ARE IN OHMS.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. Q1,Q2,TS1 MOUNTED ON COMMON HEAT SINK.
4. ALL DIODES ARE 1N5061.
5. RESISTORS ARE 5% CARBON COMPOSITION.

REVISIONS				
LTR	DESCRIPTION	DRTMN	DATE	APPROVED
A	NEW RELEASE			

NEXT ASSY	USED ON
204-022810	204-023000

ARKON Scientific Labs · Berkeley, Calif.

SCHEMATIC DIAGRAM, POWER SUPPLY MODULE

DRAWN	E. REISINGER 2/15/72
CHKD	JMR 15FEB72
SIZE	D
CODE IDENT NO.	50367
DWG NO.	204-022980
SCALE	NONE

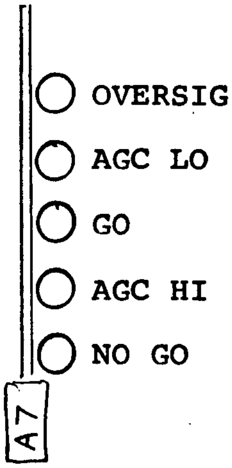
3.5 Troubleshooting Guide (cont'd)

Symptom	Corrective Action	Comments
	rotate freely, solenoid is mechanically defective (factory service.)	a known concentration of CO and adjust ZERO control until meter reads the known concentration.
7. Incorrect span (readings are too low or zero)	Check voltages at A2, A3, A4, A5, A6, Replace boards as dictated by results. If -20V at A2 - B2 is out of spec, power circuits in A1 may be at fault, if not correctable by replacing A2. Remove top cover and inspect operation of the tube switching mechanism and alignment as in 6. above.	
8. Incorrect span (readings are too high).	Check A7 indications. Check voltages at all boards as req'd. Most likely cause is incorrect span reference voltage at A5 - W19. This voltage should be +2.2V at 30" pressure, (lower at lower pressure, higher at higher pressure). If incorrect, problem is A5, A8, or incorrect supply voltages). Other cause is faulty AGC operation. A4, A5, or A6 could account for this.	

3.5 **Troubleshooting Guide** (cont'd)

Symptom	Corrective Action	Comments
9. Excessive noise, abruptly incurred.	If not accompanied by severe zero shift, this is most likely to be caused by defective components in the optics assembly, which is factory serviceable only. Check all voltages and substitute - check all boards to eliminate other possible causes. Check power supplies for excessive noise. Check A8.	Instrument may continue to be useful with increased noise as long as GO indication is maintained. If noise onset is abrupt, greater suspicion is warranted, and checking of span and zero with known concentrations of CO is advisable.
10. Excessive noise, gradually incurred.	Normal with time. If noise increases by approx. 3 times or more, a gradually declining signal is indicated. If signal drops excessively, system may be unable to maintain calibration, in which case a NO-GO will be displayed and AGC LO indicator on A7 will be lit.	If noise onset is very slow (occurring gradually over months) a degradation of the optics may be the cause. This is most likely to occur in dirty environments. In this case, optical refurbishment is called for which must performed at the factory. Temporary relief may be obtained by increasing the gain by turning trimmer on A4 CW until GO condition is reestablished. Altho noise may be higher than normal, span will remain accurate.

3.6. Diagnostic indicators on A7.



When GO is lit, no other indicator can be on.

When NO GO is lit, one or two other indicators must be on except:
GO must be out
AGC LO and AGC HI may not both be on at once.

If indications on A7 violate the above criteria, A7 is faulty.

3.6.1. OVERSIG will light if postamp signal level on A4 - F6 is $>$ 5.6VPP.
Causes of this condition are
- .1. Improper adjustment of A4 trimmer.
- .2. Faulty -20V Regulator
- .3. Faulty A4
- .4. Faulty A1 or A3
- .5. Optical assy malfunction.

3.6.2. AGC LO will light if signal level on A4 - F6 is less than approx. 1 to 2 VPP.
Causes of this condition are
- .1. Faulty -20V regulator
- .2. Dirt-contaminated optics (factory service required)
- .3. Faulty cooler servo, A1, A3.

3.6.3. GO lights when AGC and postamp signal is in proper range.

3.6.4. AGC HI indicates a circuit fault in the SPANLOK circuits. This could be caused by
- .1. Faulty A4
- .2. Faulty A5

3.6.5. NO-GO lights whenever the postamplifier or AGC signals are out of limit (see above).

3.7. Chopper Drive Belt Replacement

3.7.1. Notice - extreme care is required when handling the Kapton belt. Properly fitted, belts in good condition have ex-

3.7.1. (cont'd)

tremely long life, but kinks or dents, especially in the edges can drastically impair life.

3.7.2. Dismate power cord from side of unit (J1).

3.7.3. Remove top cover.

3.7.4. Loosen screws at bottom of motor bracket.

3.7.5. Remove old belt

3.7.6. Carefully slip new belt over drive pulley (on motor). Then rotating pulleys by hand, gradually work belt over driven pulley.

3.7.7. Using a scale or other device to measure tension, apply 0.8 $\pm$0.1. lb. of tension load while tightening screws.

3.7.8. Re-mate power cable and turn on instrument power to check running of new belt. If belt does not run true, adjust motor angle.

3.7.9 Reinstall top cover.

Table 3-1

Voltages at base of Rectifier/Power Control Assy A2.

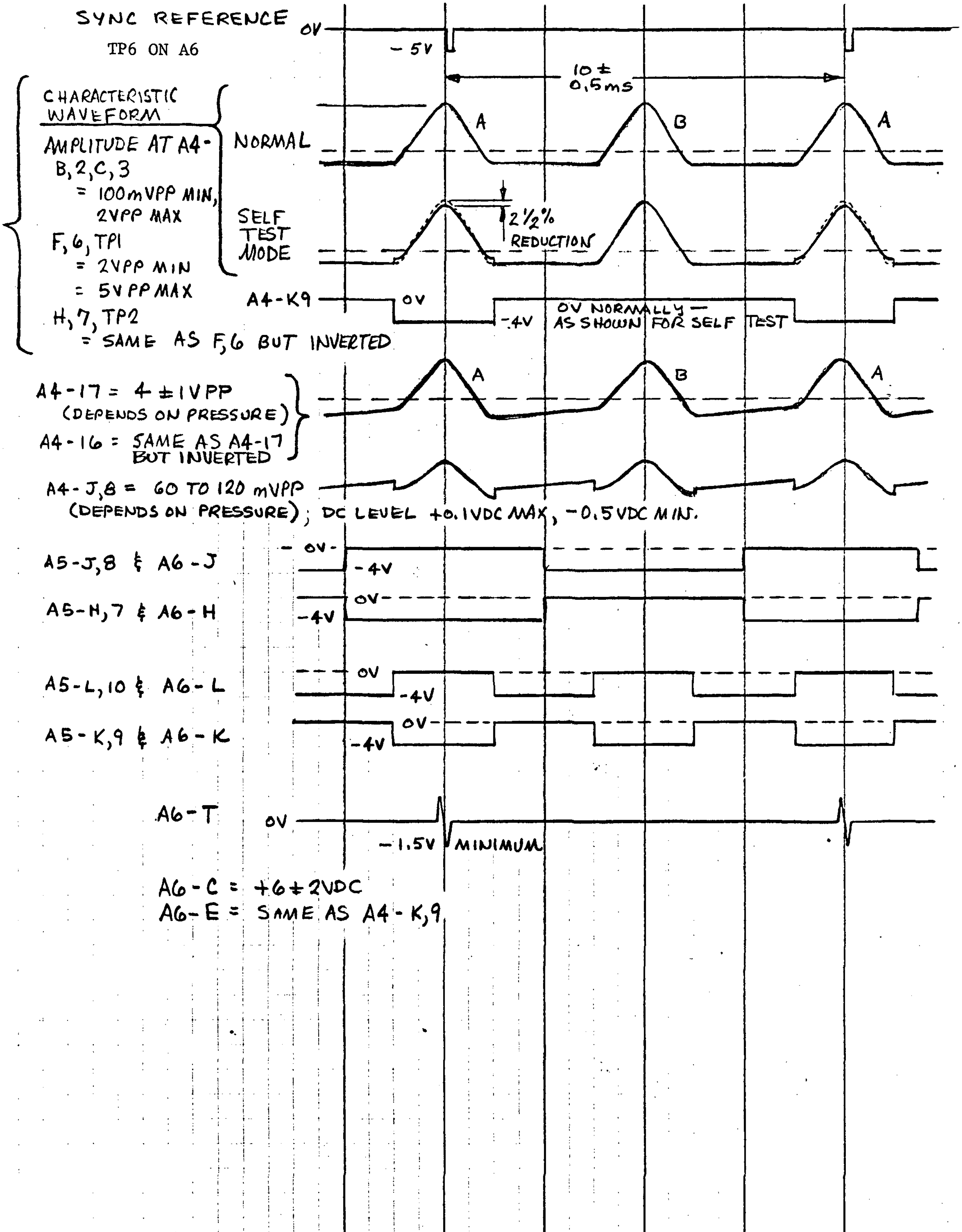
From	To	Reading	Instrument
J	Gnd	17VAC±15%	VOM
8	Gnd	17VAC±15%	VOM
L	Gnd	7.5VAC±15%	VOM
10	Gnd	7.5VAC±15%	VOM
R,14	Gnd	100VAC±15%	VOM
F,6	Gnd	+23VDC±15%	VOM
K,9	Gnd	-23VDC±15%	VOM
M,11	Gnd	-8VDC±15%	VOM
N,12	Gnd	+135VDC±15%	VOM
A,1	Gnd	0VDC	VOM
B,2	Gnd	-20±0.5VDC	VOM
D,4	Gnd	-25VDC±15%	VOM
3	D,4	+0.2V±0.1VDC	VOM
C	3	+0.7V±0.2VDC	VOM
E	Gnd	-15.0±0.2VDC	VOM

Table 3-2

Voltages as base of Voltage Regulator Assy A3.

From	To	DC Volts	Ripple	Instrument
K(+)	Gnd	+23VDC±15%		VOM
K(+)	Gnd		<1VPP	Scope
S(-)	Gnd	-23VDC±15%		VOM
S(-)	Gnd		<1VPP	Scope
M(+)	Gnd	+15±0.020VDC		DVM or Fluke
M(+)	Gnd		<5mVPP	Scope
P(-)	Gnd	-15±0.050VDC		DVM or Fluke
P(-)	Gnd		<5mVPP	Scope
Z(+)	Gnd	+135VDC±15%		VOM
Z(+)	Gnd		<1VPP	Scope
X(+)	Gnd	+100±2.5VDC		DVM or Fluke
X(+)	Gnd		<5mVPP	Scope
A(+)	Gnd	+6.0±2.0VDC		VOM
A(+)	Gnd		<0.5VPP	Scope
D(+)	Gnd	+0.6V Nom @ 75°F (+1.2V Max at high temp)		VOM
D(+)	Gnd		<20mVPP	Scope
C(+)	D(-)	0.3V Nom 0.7V Max		VOM
B(+)	C(-)	0.8V Nom		VOM
E(+)	Gnd		1.20V	VTVM

TABLE 3-3



SYNC REFERENCE
TP6 ON A6
0V
- 5V
10 ± 0.5ms
CHARACTERISTIC WAVEFORM
AMPLITUDE AT A4-
B,2,C,3
= 100mVPP MIN, 2VPP MAX
F,6,TP1
= 2VPP MIN
= 5VPP MAX
H,7,TP2
= SAME AS F,6 BUT INVERTED
NORMAL
A
B
A
SELF TEST MODE
2½% REDUCTION
A4-K9
0V
-4V
0V NORMALLY — AS SHOWN FOR SELF TEST
A4-17 = 4 ± 1VPP
(DEPENDS ON PRESSURE)
A4-16 = SAME AS A4-17 BUT INVERTED
A
B
A
A4-J,8 = 60 TO 120 mVPP
(DEPENDS ON PRESSURE); DC LEVEL +0.1VDC MAX, -0.5VDC MIN.
A5-J,8 & A6-J
0V
-4V
A5-H,7 & A6-H
0V
-4V
A5-L,10 & A6-L
0V
-4V
A5-K,9 & A6-K
0V
-4V
A6-T
0V
-1.5V MINIMUM
A6-C = +6 ± 2VDC
A6-E = SAME AS A4-K,9